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ABSTRACT

This study investigated the effects of scorekeeping on student motivation in a computer assisted arithmetic drill and practice game. A 2x2 factorial design was used which incorporated the four treatments formed by time score (present and absent) and rank score (present and absent). Selected on the basis of their previous experience with the procedure of carrying in addition problems, the subjects were 52 second grade students who were randomly assigned to the four treatments. After a brief introduction and demonstration of the rules of the game, each student could elect to play further rounds to a maximum of 15 minutes. Motivation was measured by the number of rounds elected. An analysis of variance calculated for the number of rounds played indicated that there was no significant treatment effect. Discussion of the results and suggestions for further studies conclude the report. (Author/RP)

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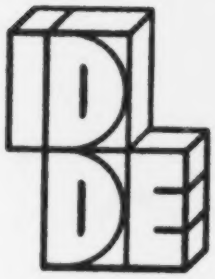

INSTRUCTIONAL DESIGN, DEVELOPMENT, AND EVALUATION

WORKING PAPERS

THE EFFECTS OF SCOREKEEPING ON STUDENT MOTIVATION IN A COMPUTER-ASSISTED ARITHMETIC DRILL AND PRACTICE GAME

by

Charles M. Spuches
Charles M. Reigeluth

IDD&E Working Paper No. 21
August, 1985

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ABSTRACT

This study investigated the effects of scorekeeping on student motivation in a computer assisted arithmetic drill and practice game. A 2 x 2 factorial design was used which incorporated the four treatments formed by time score (present and absent) and rank score (present and absent). Subjects were 52 second grade students who were randomly assigned to the four treatments. After a brief introduction and demonstration of the rules of the game, each student could elect to play further rounds to a maximum of fifteen minutes. Motivation was measured by the number of rounds elected. An analysis of variance calculated for the number of rounds played indicated that there was no significant treatment effect. Discussion of the results and suggestions for further studies are provided.

INTRODUCTION

The infinite patience of the computer and its ability to provide materials at appropriate levels of difficulty have contributed to its use in the drill and practice mode, particularly in the area of mathematics. Based on the premise that the student has learned the basic concept, principle or procedure, the computer program provides practice to enable the student to internalize and further develop command of the material. A major concern in the design of such programs is the aspect of motivation. While it is necessary to provide continuous and immediate feedback for correct answers and constructive feedback for incorrect answers, it must be done in a way that encourages the student to continue at increasingly higher levels of difficulty and thus benefit from the program.

In the last several years, there have been increasing interest in and availability of drill and practice programs set in a game context. It has been suggested that certain aspects of games have a significant effect on student motivation. Attempts have been made to identify the elements of computer games that contribute to their appeal and to determine their relative influence on motivation as well as to establish prescriptions for including these elements in educational games.

To our knowledge, there have been only three studies (Malone, 1981) that have addressed these concerns in a controlled setting. In this series of three studies, attempts were made to discover the features that make certain computer games fun to play. The report of these studies includes a theory of intrinsically motivating instruction which prescribes ways to incorporate into educational computer games the features that make computer games fun to play.

Malone discovered that the two features that had the highest correlations with game preference were the presence of a goal and scoring. Since the concept of a game by definition implies there be a purpose or goal to be achieved, it would seem that further work on goals should relate to the design and communication of the particular nature of a game's goals. A more important area of inquiry seems to be the nature and role of scorekeeping in educational computer games. The feature of scoring had a .56 correlation ($p<.01$) with game preference in the studies described above.

Scorekeeping provides several important elements to an educational computer game. Scoring allows players of a game the opportunity to evaluate their performance by providing clear feedback that continuously lets them know how well or how poorly they are doing at any given point in the game (Csikszentmihalyi, 1975). Students may begin play at an appropriate but low level of difficulty. Scorekeeping then provides the encouragement to proceed to increasingly difficult levels. The element of scorekeeping also provides an aspect of uncertainty to the game by encouraging the student to succeed at a higher level of challenge. This challenge is different in difficulty but not in kind from the earlier levels of play. Because the purpose of drill and practice games is automatizing previously learned skills (Heinich, Molenda, and Russell, 1982), those elements that contribute to students' persistence on a task are essential. Since motivating feedback

following a response contributes to persistence and maintenance of performance (Keller, 1983), scorekeeping appears to be an appropriate and important motivational element for investigation.

The previous three studies (Malone, 1981) have not, however, adequately measured the effect of scorekeeping in particular on motivation. There were two major problems with those studies. The first is that the attempt to measure the effect of several variables in a game at one time has, in effect, resulted in the comparison of essentially different games. Second, the studies cited have not adequately controlled for multiple-treatment interaction (Campbell and Stanley, 1963). In Malone's studies, a series of variables, which included scorekeeping, was presented to students consecutively and in a cumulative manner, making it impossible to obtain an accurate measure of the effects of each of those variables individually. Therefore, while claims for the influence of scorekeeping are intuitively appealing, the effect of scorekeeping on student motivation has not been properly assessed and should be considered tentative at best.

The purpose of this study, then, is to examine the effect of scorekeeping on student motivation in a computer drill and practice game. Scorekeeping is understood to be a measure of a student's progress toward a goal. There are two kinds of score: objective and evaluative. For example, a time score is objective whereas a rank score is evaluative. Time score is defined here as the time it takes the student to complete one round of the game (not necessarily real time). Rank score is defined as a rating the students receive which is based on their playing time. The time score provides the students with objective feedback on their performance much like that provided to someone finishing a long-distance race. Rank score provides a qualitative categorical rating of the students' performance, such as high, medium, or low. While the time score is objective, reporting a measure of a performance based on a neutral scale, the rank score provides a comparative report of a student's performance. In this study, both types of scorekeeping are manipulated while all other variables are held constant.

It is hypothesized that:

1. The presence of a time score will result in greater student motivation than no score at all.
2. The presence of a rank score will result in greater student motivation than no score at all.
3. The effects of time and rank score will be additive when used together (i.e., no interaction).

METHOD

Students

The subjects of this study were 52 second-grade students from three classes at a suburban elementary school in central upstate New York. This sample represents above average ability and motivation with regard to math and slightly above average motivation and experience with regard to the use of computers as educational tools. All of the students had experience with computers in the area of math drill-and-practice programs since first grade and appeared enthusiastic about participating in the study. The students' previous experience included groups of two to three students working on math programs under the supervision of a parent volunteer.

Students were selected on the basis of their previous experience with the procedure of carrying in addition problems. While all students had learned the procedure for carrying, because of variations in ability, some developed greater facility with it than others. For the present study, groups of four students were randomly selected from their classrooms and randomly assigned to one of the four treatment groups as they entered the testing room.

Design

A posttest-only experimental design and a 2 x 2 factorial design were used for this study. The factors were two levels of scorekeeping—time score (present and absent) and rank score (present and absent). The statistical design is shown in Figure 1.

Insert Figure 1 about here

Task and Materials

Each student was presented with an arithmetic drill and practice game on an Apple IIe computer with color monitor. The game consisted of two-digit addition problems which required the procedure of carrying. Each round of the game consisted of ten addition problems. One of the ten triangles at the top of the screen would be removed from the screen as the student satisfactorily completed a problem. Boxes were provided as a prompting device and indicated to the student each step of the problem. If an error was committed in either the process of addition or carrying, an "X" would appear in the particular box to cross out the wrong answer. After a delay of three seconds, the "X" would be erased and the student could re-enter the correct response. At the end of each game a screen menu would prompt students to elect to either stop or continue play for another round. The screen design is represented in Figure 2. The speed of the clock was preset, and each problem was randomly generated by the computer program.

Insert Figure 2 about here

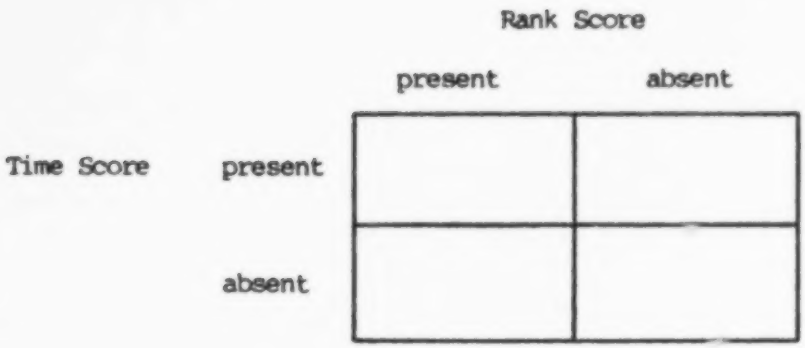


Figure 1: 2 x 2 Factorial design

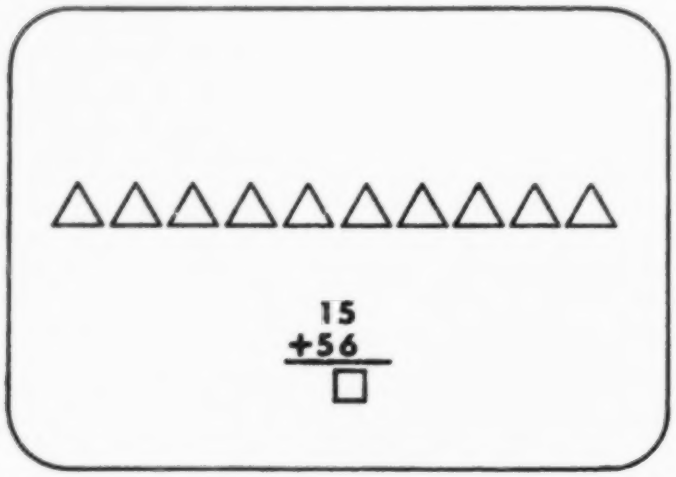


Figure 2: Screen design for presentation of problems

Treatments

There were four treatment groups (see Figure 1 above): time and rank score, time only, rank only, and no time or rank score. The structure and content of the game remained identical across treatment groups. At the end of a round the time/rank score group was presented with the time it took to complete that round and a rank which was based on that time. The time score only group received only the time it took to complete that round, and the rank score only group was only presented with a ranking of their performance. In this game, the rankings range from "slug bug" to indicate a low or slow score to "super speed demon" which represents a high or fast score. The no time/no rank group didn't receive any form of score. The screen designs for the scoring of the time and rank, time only, and rank only treatments are provided in Figure 3.

Insert Figure 3 about here

Tests and Measures

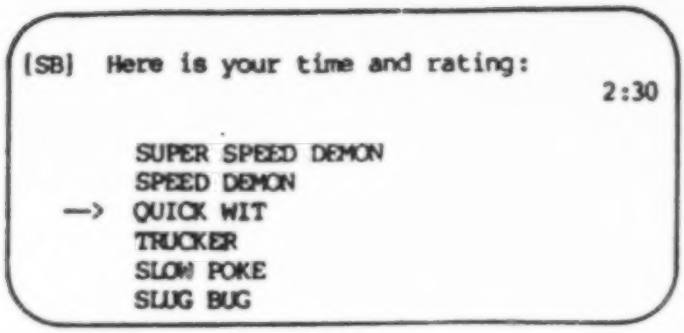
The number of rounds each student played was recorded by a research assistant and used as a measure of motivation. Information about student attitude toward the game and the scorekeeping were taken in a brief post-treatment interview. The interview collected data regarding the students' satisfaction with the game, their opinion about the game's best feature, suggestions for making the game better, and their attitude toward the particular scorekeeping treatment they received. The interview instrument is provided in Figure 4.

Insert Figure 4 about here

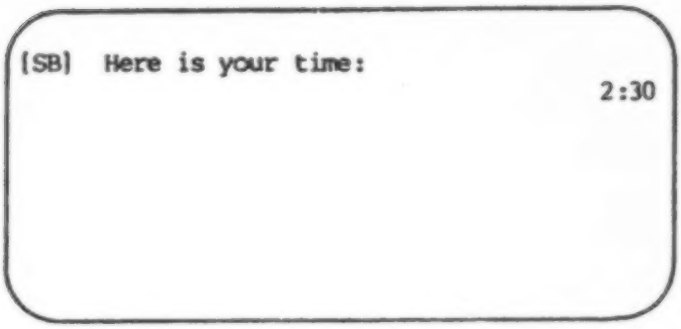
Procedure

The students were randomly selected to report to the experiment room in groups of four. Each student was randomly assigned to one of the four versions of the math drill and practice game. Four computers were arranged at four areas of a large work room so that students working at one station would not be distracted by students working at the other stations. Before playing the game, research assistants located at each station presented each student with a brief tutorial which demonstrated the game's procedure. The research assistants also recorded the amount of playing time and the number of rounds played by each student. The instructions provided to each of the research assistants and a description of the tutorial are provided in Figure 5. The instructions were followed very well.

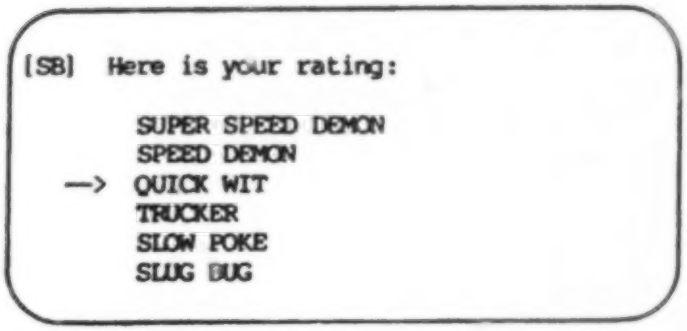
Insert Figure 5 about here



Time/rank score



Time score



Rank score

Figure 3: Score presentation screens for time/rank, time, and rank score treatments

OBSERVATION/INTERVIEW FORM

GROUP_____ STUDENT_____

PLAYING TIME_____minutes MALE ( ) FEMALE ( )
(15 minute maximum)

NUMBER OF GAMES_____ OBSERVER_____

----------ASSISTANTS DO NOT WRITE BELOW THIS LINE----------

1. Tell me how well you liked this game? Would you say you:

   1. Didn't like it at all...( ) 3. Liked it very much.....( )

   2. Liked it.....( ) 4. Don't know.....( )

2. What about this game did you like best? _____

3. Can you think of anything that would make this game better (more fun to play)?

   _____

4. What about this game made you want to keep playing?

   _____

(TR) 5a. Did seeing your time score (how long it took you to play each game) make you want to keep playing the game?

Yes ( ) No ( ) Don't know ( )

(TR) 5b. Did seeing your rating (slug bug, speed demon, etc.) make you want to keep playing the game?

Yes ( ) No ( ) Don't know ( )

(T) 6. Did seeing your time score (how long it took you to play each game) make you want to keep playing the game?

Yes ( ) No ( ) Don't know ( )

(R) 7. Did seeing your rating (slug bug, speed demon, etc.) make you want to keep playing the game?

Yes ( ) No ( ) Don't know ( )

(0) 8a. If you had seen your time score (how long it took you to play each game), would it have made you want to keep playing?

Yes ( ) No ( ) Don't know ( )

(0) 8b. If you were given a rating (like slug bug, speed demon, etc.), would it have made you want to keep playing?

Yes ( ) No ( ) Don't know ( )

Figure 4: Observation/Interview Instrument

RESEARCH ASSISTANTS

PROCEDURE:

==>You (ASSISTANT) have four things to do:

1. Say hello and introduce yourself (first names) to the student as they sit down in front of the computer. You may tell them that this is a new math game and we are trying it out to see how much fun it is to play.

2. Present the rules of the game to the students. ("Here's how it works.")

3. On your observation sheet, record the length of time they play the game (to a maximum of 15 minutes) AND the number of games they play.

4. When they are done playing the game, congratulate the student for a good job and take them out to the hall (with your observation form) to talk to Mr. Spuches.

As your first student is seated at your computer, the computer program will have already been booted and the following screen will be displayed:

[Would you like me to tell you the rules?]

==> Assistant types "Y"

As the program explains the rules of the game you should read the rules out loud to the student. The rules are relatively simple and most of the students will have had some experience with this type of game so you shouldn't need to spend very long on this. Be attentive to the student and proceed to the next frame after you have confirmed they are with you (a simple OK? should do it).
This demo should take approximately 60 seconds.

[I will show you a problem. You must type the answer as quickly as you can -SB-]

==>Assistant types SPACE BAR

[First add the ones -SB-]

==>Assistant types SPACE BAR

[Next we carry the ten by typing a "1" -SB-]

==>Assistant types SPACE BAR

Figure 5: Instructions to Research Assistants

[Then we add the tens and type in the answer
from right to left]

*==> At this point pause briefly to let the student know you are ready to begin ("Ready to start?" should do it).

==>Assistant types SPACE BAR

[I will keep track of your total time.
GET READY (repeated THREE times]

**==>Begin timing the student as soon as the first problem appears on the screen. The student will now play the game.
AND
**==>Record the number of games they play.

At the end of each game the student may be presented with their time and/or rank score or no score at all, depending on the version they are playing. If a score is presented follow the next directions. (If no score is presented you will skip the following step and be taken to the student choice screen).

==> After their score is displayed, pause for about three seconds,
say "OK" and
==>type SPACE BAR

[You may choose what you would like to do next.

1. Play speed game again

2. Stop playing]

The student should type in their choice. If they do not respond to the screen or seem confused, simply read the screen to them and remind them to type in their choice.

==>Complete your observation form. Congratulate the student for a good job and bring them to Mr. Spuches along with you observation form.

==>If you haven't already done it, press No. 2 ("STOP PLAYING") and SPACE BAR. This will bring the program to the explanation of the game's rules for the next student.

While you should be pleasant and relaxed with the students, your interaction and dialogue should closely follow the outline above. Don't congratulate or encourage students until they have completely finished.

Figure 5: continued

Following these instructions, each student was allowed to play as many rounds as they wished, up to a maximum of 15 minutes. After each round, a screen displayed the option for the student to either play another round or to stop playing.

When a student indicated that they wanted to stop playing, the number of rounds played was recorded, and the student was brought to a near-by location and interviewed individually by the researcher.

RESULTS

Measures of Motivation

The average number of rounds played in each of the four treatment groups is shown in Table 1. It had been hypothesized that the richer treatment, i.e., the combination of time and rank score, would result in increased motivation for the students to play the math drill and practice game. However, the analysis of variance revealed that all differences were far from significant.

Insert Table 1 about here

Measures of student attitude recorded in the post-treatment interview were consistent with the means for the number of games played. As shown in Table 2, students in the combined time/rank score treatment indicated the poorest overall attitude toward the game. In contrast, students in the no-score treatment appeared to derive the most enjoyment directly from playing the math game. This group indicated strongly that they found the opportunity to use and review previously learned math skills in a game format to be the most attractive feature. In response to the question regarding the particular aspect of the game that made them want to keep playing, the no-score treatment, again by a wide margin, indicated their direct enjoyment of working with math skills and problems. While a considerable percentage of the students in both the time and the rank score treatment groups indicated they found that the aspect of trying to get a better score in succeeding games made them want to keep playing, few students in the time/rank treatment group said this was an important aspect.

Insert Table 2 about here

DISCUSSION

Math drill and practice games appear to be the most frequently used form of computer assisted instruction. There is much interest in the application of computer game features to make these and all educational computer games more enjoyable as well as educational. Previous studies have claimed that the feature of scorekeeping is highly influential on student motivation in such contexts. They have not , however, controlled for other variables while measuring the effect of scoring on motivation. In the present study, scorekeeping was operationalized as a time score and a rank score and, based on previous research and theory, it was hypothesized that

Table 1: Means, (SD), and n for the number of rounds played.

		Time: No	Time: Yes		
Rank	No	3.08 (.50) 13	3.40 (.55) 13	3.23 (.36) 26	F = .15 p = .70
	Yes	3.31 (.43) 13	2.80 (.50) 13	3.04 (.34) 26	
		3.20 (.32) 26	3.08 (.38) 26		
		F = .05 p = .82			Interaction: F = .70 p = .41

Table 2: Summary of selected responses from the post-treatment interview (in percents).

1. Tell me how well you liked this game. Would you say you:

	Time	Rank	Time/Rank	No Score
A. Didn't like it at all	0	0	0	0
B. Liked it	30.77	23.07	46.15	23.07
C. Liked it very much	69.23	76.92	53.85	76.92
D. Don't know	0	0	0	0

2. What about this game did you like best?

	Time	Rank	Time/Rank	No Score
Enjoyed using/reviewing math skills and playing math games	61.53	69.23	61.53	84.61
Challenge; Liked trying to figure the problems out real fast	7.69	0	15.38	15.38

4. What about this game made you want to keep playing?

	Time	Rank	Time/Rank	No Score
Fun to play; Knew addition and carrying well; Fun to practice	30.76	46.15	30.77	69.21
To see if I could get a better score	38.46	23.07	15.38	7.69
Misc.	0	15.38	0	7.69
Don't know	7.69	7.69	15.38	0
NA--one game only	23.07	7.69	38.46	15.38

the presence of either time score or rank score would result in greater student motivation than no score at all, and that the combined use of time and rank score would provide greater motivation than no score at all.

The first and second hypotheses, that the presence of either time score or rank score will result in greater student motivation than no score at all, were not confirmed. Moreover, although a high percentage of students in the rank score treatment group indicated a positive attitude toward the game, an equal percentage of students in the no-score treatment indicated that they, too, had a positive attitude toward it. The percentage of students in the time score treatment who indicated a high level of satisfaction with the game was lower than that for the rank and no-score treatments.

The third hypothesis, that the effects of time and rank score will be additive when used together, was not confirmed. Since a level of significance was not reached, the results suggest that the expectation for an additive effect to occur when time and rank score are used together may be unreasonable, at least under the present conditions.

The results of this study suggest the following conclusions. Elementary school students find the actual use of math skills and their practice in a game-like situation to be intrinsically motivating and the introduction of scoring may actually inhibit the intrinsic enjoyment derived from this activity. Also, the use of computer assisted drill and practice games should be used to enhance students' command of the basic skills and may be, in and of themselves, highly motivating. The use of scorekeeping, however, requires further investigation, especially with regard to its relation to student characteristics. Future studies, then, should not address the question "is the use of scorekeeping an appropriate motivational element in computer assisted educational games," but rather "when and for whom are the various types of scorekeeping useful?"

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